JPEG 2000 Present and Future Use at DigitalGlobe

JPEG 2000 Symposium

June 23, 2004

Overview

- DigitalGlobe Web Distribution Initiative

- WorldView Description

- JPEG 2000 issues for WorldView

Web Distribution Initiative

- Summer 2003—Desire to provide of Near Visually Lossless imagery products over United States to web-based vendors
  - GlobeXplorer, Keyhole

- Evaluated two software solutions in terms of
  - Time to encode/decode
  - Compression Quality – Mean Square Error, and Peak Signal to Noise Ratio
  - Support of DigitalGlobe products
    - Noted Problem: limited support of MS imagery (compression engines and viewers)
      - Multi band products—Solution: compression of individual bands
      - Viewers: Assume RGB band order using 3 band data.

- Implemented GeoJP2 solution (at that time from Mapping Sciences)

JPEG 2000 Web Distribution Features

- DG provides orthorectified pan-sharpened products to vendors
  - 8K x 8K image segments
    - No tiling
    - UTM
    - 60 cm GSD
    - 1:50,000 scale accuracy
  - 10:1 compression provides Near Visually Lossless data

- Production
  - Currently mining archive for best imagery
  - Approximately 50 images/day
  - Delivery on Firewire drives
  - Future goal of ftp delivery

- Geographic support
  - We include associated JPW files and metadata files along with GeoJP2 internal support of GeoTIFF tags
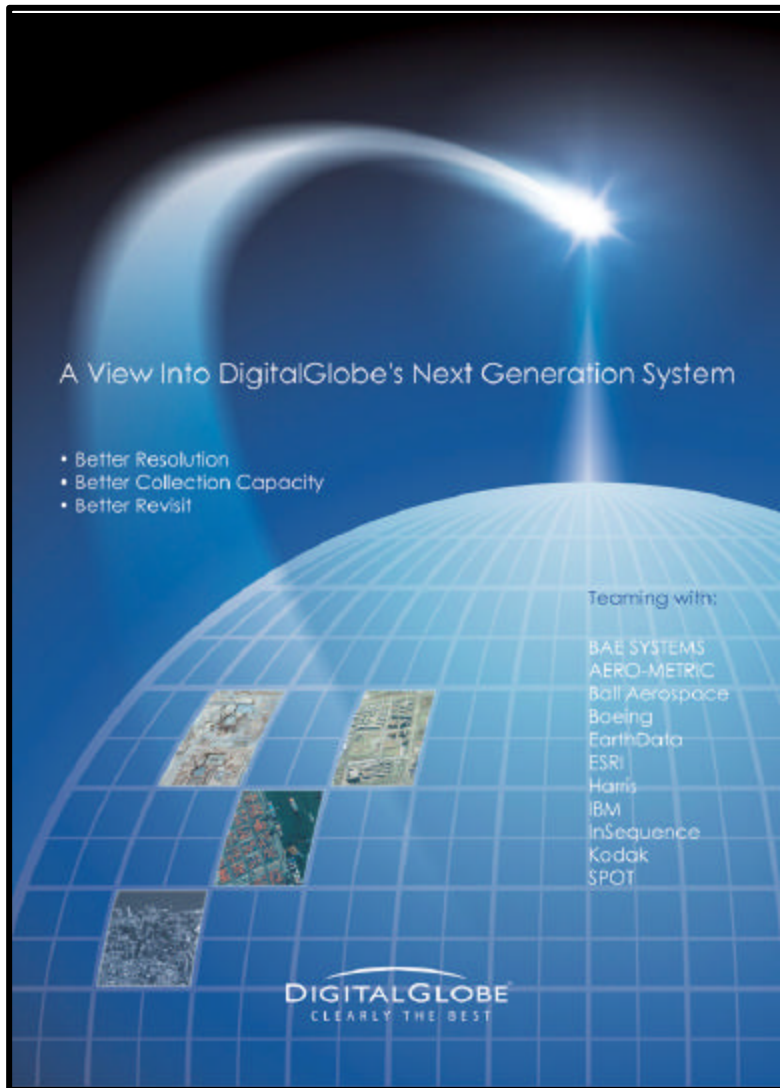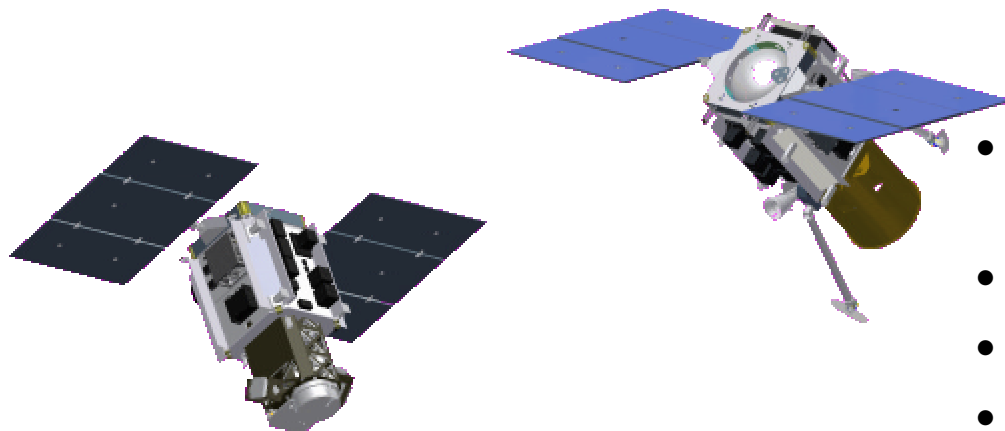
DigitalGlobe's Next Generation System:

WorldView

1-day Revisit at 1-Meter ◆ Improved Geolocational Accuracy ◆ World's Highest Resolution Commercial Satellite Imagery ◆ < 50-cm Panchromatic Resolution ◆ <2.0-m Multispectral Resolution ◆ 3.5x More Imaging Capacity ◆ Improved Agility ◆ Low Risk Space Segment ◆ Commercial Strength and Innovation ◆ Multi-sensor Data Sourcing ◆ New Customer Products ◆

Key Players
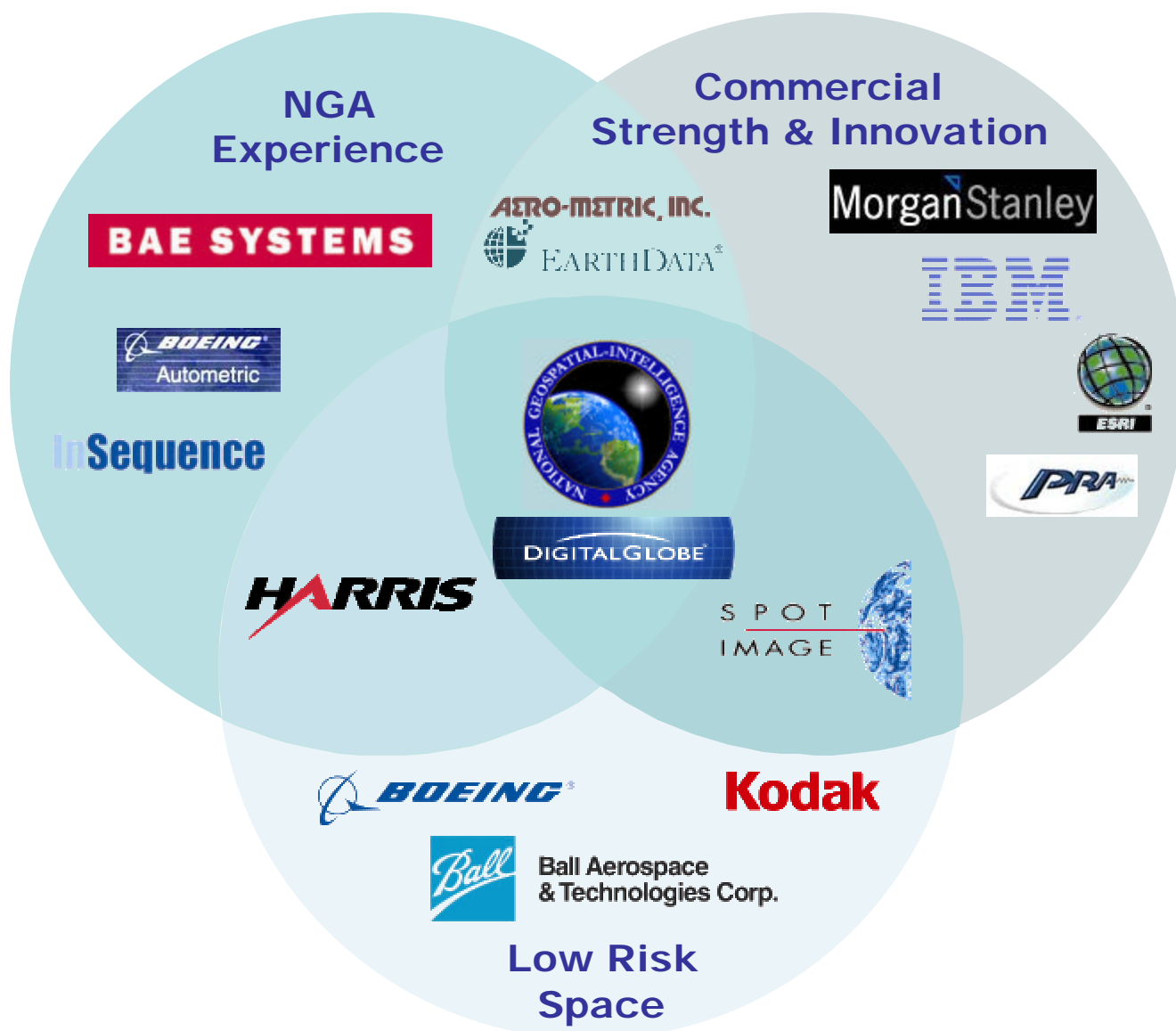
QuickBird & WorldView Satellites

Next Generation Satellite

- Even Better Resolution
  - (sub-half meter)
- Substantially Better Agility
- 3.5X More Mono Capacity
- Improved Revisit
  - Daily at 1-meter or better
- Improved Geolocation Accuracy
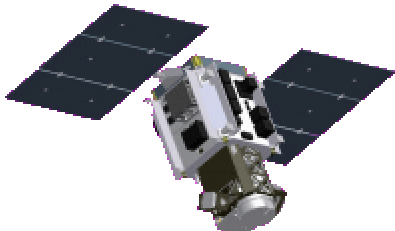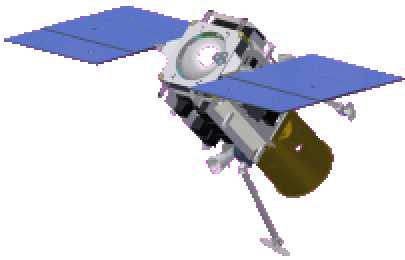 - Better than 10-meter CE90 standalone

QuickBird

- Worlds Highest Resolution Commercial Imagery (61-cm Pan)
- Launched Oct. 2001
- >315,000 Scenes In Archive Since Jan '02
  - Covering more than 96 million km²
  - Adding 1 million km²/week

QuickBird & WorldView Comparison

| Parameter	QuickBird	Next Generation Satellite(s)
Operational Altitude	450 km	770 km
Weight Class	2000 lbs	5700 lbs
Spectral Characteristics	Pan / 4 MS	Pan / 8 MS
Panchromatic / Multispectral Resolution (nadir)	.60 /2.4 meters	.50 /2.0 meters
Standalone geolocation accuracy (CE90)	23 meters	<10 meters
Avg. revisit at 1m resolution (40° latitude target)	2.5 days	1 day
Swath Width	16.5 km	16 km
Monoscopic Area Capacity	1x	>3.5X
Single-Pass Monoscopic Area Coverage	1 x 10 Scenes (<30° off nadir)	4 x 4 Scenes (<40° off nadir) 1 x 10 Scenes (<40° off nadir)
Single-Pass Stereoscopic Area Coverage	Single Scene (<10° off nadir)	2 x 2 Scenes (<30° off nadir) 1 x 10 Scenes (<30° off nadir)
Primary Attitude Control Mechanism	Reaction Wheels	Control Moment Gyros
Onboard Storage	128 Gbits	1600 Gbits
Wideband Link Rate	320 Mbps	800 Mbps

What Do Satellite Enhancements Mean?

- Accuracy
  - Standalone CE90 supports 1:10,000 map production without control
  - Higher relative accuracy supports production of better than 1:2,400 scale (1"=200') maps using available ground control
- Revisit
  - Ability of the WV to revisit a given target daily at 1 meter resolution or better
  - Much better chance of collection in high cloud regions
- Area collection capacity + storage + downlink data rate
  - Over 3.5x the total capacity of QuickBird, so faster collection of customer orders
- Agility (5-10x) + altitude (1.7x QuickBird)
  - MUCH greater <u>local</u> collection capacity
  - MUCH greater capacity to collect competing orders within the same region
  - MUCH faster collection of orders in high competition areas

WorldView Band Selection

- Pan Band
  - 50 centimeter resolution at Nadir
- Multispectral Bands
  - 2 meter resolution at Nadir

- Multispectral Bands include
  - Blue   (analogous to QuickBird Blue)
  - Green   (analogous to QuickBird Green)
    - *Narrowed to focus more precisely on green to coordinate with blue and yellow bands*
  - Red   (analogous to QuickBird Red)
  - Near-Infrared1   (analogous to QuickBird Near-IR)
  - Coastal   (new)
  - Yellow   (new)
  - Red Edge   (new)
  - Near-Infrared2   (new)

Graphic of WorldView Bands
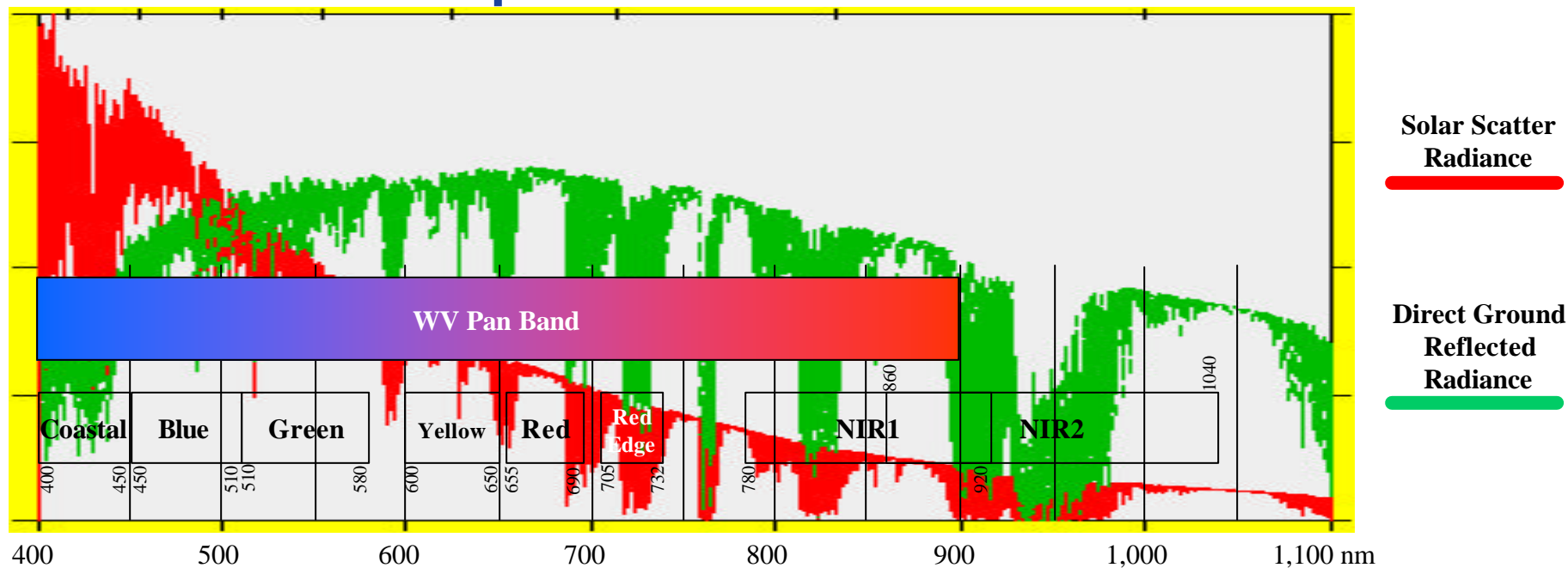
Coastal

- Chlorophyll absorption, blue light scattering, bathymetry; Supports vegetation identification and analysis; bathymetric studies based upon chlorophyll and water penetration characteristics.

Yellow

- Used to identify "yellow-ness" characteristics of targets, important for vegetation applications. Also, will assist in development of "true-color" hue correction for human vision representation.

Red Edge

- Aids in analysis of vegetative condition. Directly related to plant health revealed through chlorophyll production.
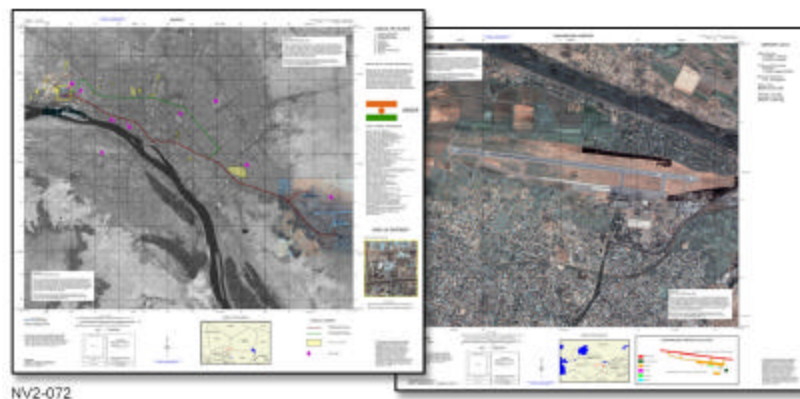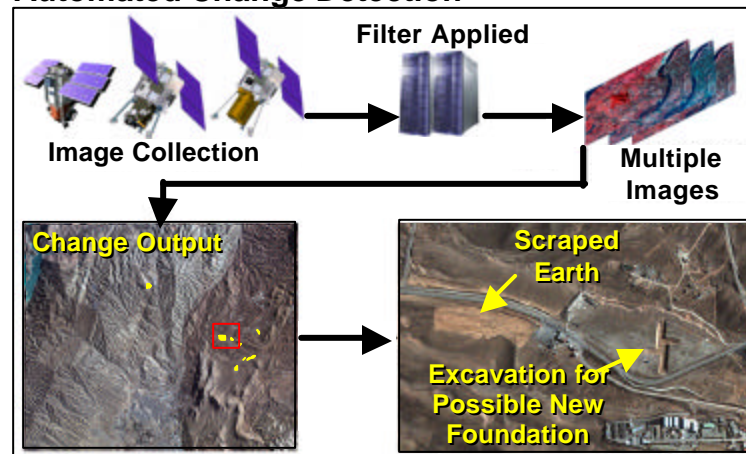
NIR2

- Overlaps NIR1 band but less affected by atmospheric influence. Supports vegetation analysis and biomass studies.

Building New Customer Products

Product	Agriculture	Civil Govt	Forestry	Vis/Sim	Foreign Govt	U.S. Govt
Basic Imagery	✓				✓	✓
Ortho Imagery	✓	✓	✓	✓	✓	✓
Stereo Imagery			✓			
DEMs		✓	✓			
Aerial Photography	✓	✓				
SPOT Imagery	✓	✓				
Street Centerlines		✓				
Land Use/Land Cover	✓	✓	✓	✓	✓	
Pervious/Impervious Surfaces		✓				
3D Buildings				✓		✓
3D Fly-thrus				✓		
Tree Crown	✓		✓			
Fuels Loads			✓			
AgroWatch Grn Vegetation Index	✓				✓	
AgroWatch Scout Aid	✓					
AgroWatch Soil Zone Index	✓					
CIB						✓
DTED						✓
Gridded Airfield Graphics (GAG)					✓	
Image City Maps (ICM)					✓	✓

Automated Change Detection

Filter Applied — Image Collection — Multiple Images — Change Output — Scraped Earth — Excavation for Possible New Foundation

NV2-072

Gridded Airfield Graphics and Image City Maps

Summary

- WorldView will be the world's highest resolution commercial imaging satellite with 50-centimeter panchromatic resolution and 2.0-meter multispectral resolution
- WorldView will offer dramatic improvements over current commercial capability in
  - Timeliness
  - Capacity
  - Agility
  - Accuracy
  - Multisourcing
  - Product Diversity

JPEG 2000 Issues for WorldView

- Need to support NGA/DoD with NITFS Preferred JPEG2000 Encoding format (NPJE)

- Features of NPJE might not be desirable to commercial customers
  - E.g. 1K x 1K tiling

- Expected imagery volumes may involve mixed hardware/software solution

- Will need to support commercial customers with native JPEG 2000 format